Original Article

A Prospective Study Of Functional Outcome Of Fractures Of Short Tubular Bones Of Hand Treated By Mini-Plating

R.Sakthivel[1], N. Nandha Kumar[2], S.Mohamed Azeem[3], B.Manimaran[4*]**

1. Dr R.Sakthivel, Assistant Professor, Department of Orthopaedics, Government Erode Medical College Hospital, Perundurai, Erode, Tamilnadu, India. Email: drsakthivelr74@gmail.com
2. Dr N. Nandha Kumar, Assistant Professor, Department of Orthopaedics, Government Erode Medical College Hospital, Perundurai, Erode, Tamilnadu, India. Email: drnandha1979in@yahoo.com
3. Dr S. Mohamed Azeem, Assistant Professor, Department of Orthopaedics, Government Erode Medical College Hospital, Perundurai, Erode, Tamilnadu, India. Email: azeem_azeemmd@yahoo.co.in
4. Dr B.Manimaran, Assistant Professor, Department of Orthopaedics, Government Erode Medical College Hospital, Perundurai, Erode, Tamilnadu, India. Email: manikarthik52@gmail.com

***Corresponding Author:
Dr B.Manimaran, Assistant Professor, Department of Orthopaedics, Government Erode Medical College Hospital, Perundurai, Erode, Tamilnadu, India. Email: manikarthik52@gmail.com
DOI: 10.47750/pnr.2023.14.02.150

Abstract

Introduction: Metacarpal and phalangeal fractures are always common in adolescents and young active individuals. Aim of the study is to assess a prospective study on functional outcome of closed metacarpal fractures treated with plates and screws. Materials and Methods: Selected patients for study is examined according to protocol, associated injuries noted and clinical examination and lab investigations carried out in order to get fitness for surgery. Consent of the patient will be taken for surgery. Patient will be followed till Union is achieved clinically as well as radiologically. Time required for union, range of motion of surrounding joints and complications occurred before / during / after surgery will be studied in detail. Results: 20 patients were included in this study. 5 patients had multiple metacarpal fractures (25% cases). Right hand was involved in 14 of the patients (70%). 1 out of 20 were female patient (10%). All the 20 patients who underwent open reduction and internal fixation with plate osteosynthesis for unstable metacarpal and phalangeal fractures achieved bone union (100%). In most of the cases bony union was seen between 6-8 weeks, average period being 7.2 weeks (range 6-12 weeks).Functional outcome assessed by ASSH (American Society for Surgery of the Hand) TAF (Total Active Flexion) score was excellent in 16 patients (80%), good in 2 patients (10%), fair in one patient (5%), poor in one patient (5%). The overall results are satisfactory. Conclusion: Plate and screw fixation is a good option for treating closed unstable metacarpal and phalanx fractures, where other modalities of fixation are less effective.

Key Words: Metacarpal, Tubular Bones, mini-plating, osteosynthesis, bone union

INTRODUCTION:

Fractures of bones of the hand are among the commonest fractures in humans, but their management varies widely in the different regions of the world. This variability is due to many reasons, including availability of resources, social factors, geographic constrains, surgeon preference and experience, and local practice patterns(1). Developing countries are more likely to apply less expensive methods of managing hand fractures. Fractures of metacarpal and phalangeal bones of the hand constitutes between 14 to 28 % of all visits to the hospital following trauma by various means like assault , road traffic accidents, industrial accidents , agricultural accidents etc(2). Too often these metacarpal and phalangeal fractures are neglected or treated as minor injuries and results in major disability and deformity with permanent disability and handicap(3). Hand fractures can be complicated by deformity from no treatment, stiffness from over treatment, and both deformity and stiffness from poor treatment(4-5). Fracture healing in the hand is not an isolated goal rather the functional result is of paramount importance. Recent studies have shown good functional results with surgical treatment of metacarpal and phalangeal fractures using miniplates and screws as compared to conservative treatment or K -wire fixation(6-8). This study involves evaluating functional and radiological outcome of metacarpal and phalangeal fractures treated with miniplates and screws.

Metacarpal and phalangeal fractures are most common fractures of upper extremity. 70% of these fractures commonly occur between the ages of 10-45 yrs(2,9-10). Early in 20th century these fractures were all managed nonoperatively. Operative fixation of hand fractures was limited for the past 4 decades. Today most fractures are managed successfully by non operative modalities as most fractures are functionally stable before and after closed reduction and are well managed with protective splint and early mobilization. In spite of numerous treatment modalities SWANSON states "Hand fractures can be complicated by deformity from no treatment, stiffness from overtreatment, both deformity and stiffness from poor treatment" Increased popularity of operative treatment at present are due to the following reasons: a. Improved designs of implants and materials, b. Availability of self tapping and miniature screws of 1mm diameter that can be placed percutaneously, c. Availability of low profile plates which are easy to contour and cut but can withstand sufficient loads, d. Better understanding of biomechanical principle of internal fixation, e. Demanding public expectations, f. Availability of improved radiographic imaging by cross section CT permitting multiplanar analysis of fracture and g. Availability of hand specialist and hand therapist(11-13)

In general, risk of permanent stiffness should be prevented by avoiding prolonged immobilization. However, aggressive attempts of internal fixation leads to tendon adhesion, soft tissue damage, infection and need for implant removal. Ultimate outcome depends on judicious selection of cases for operative fixation which gives better outcome than non operative management .

Indications for plate fixation of the metacarpals are

1. Multiple fractures with gross displacement
2. Displaced diaphyseal transverse, short oblique, or short spiral fractures
3. Comminuted intraarticular and periarticular fractures -displaced
4. Comminuted fractures with shortening or malrotation or both

AIM OF THE STUDY:

Metacarpal and phalangeal fractures are always common in adolescents and young active individuals. The functional outcome of these fractures depends upon severity of injury and the achievement of treatment. Mostly these are treated by conservative methods. In an unstable fractures where closed reduction and final outcome are unsatisfactory are treated by operative measures. There are many surgical options for treating metacarpal fractures like K-wire fixation, interosseous wiring, plateosteosynthesis, etc.

In this study we assess a prospective study on functional outcomeof closed metacarpal fractures treated with plates and screws using the American Society for Surgery of the Hand (ASSH) Total Active Flexion (TAF) score

OBJECTIVES OF THE STUDY

- To study the various mechanism and pattern of metacarpal fractures and their surgical management with plates & screws
- To study the functional outcome of metacarpal fractures treatedsurgically.
- To study the technical difficulties and complications of metacarpalfractures treated surgically

MATERIAL AND METHODS

Adult patients with metacarpal fractures admitted to Government Erode Medical College Hospital, Perundurai was taken up for study after obtaining the consent. Patients with metacarpal fractures are selected after clinical and radiological analysis during the period of study from December 2020 to December 2022. All the patients selected for study was examined according to protocol, associated injuries noted and clinical examination and lab investigations carriedout in order to get fitness for surgery. Consent of the patient was taken for the surgery. Patient were followed till Unionis achieved clinically as well as radiologically. Time required for union, range of motion of surrounding joints and complications occurred before / during / after surgery will be studied in detail.

INCLUSION CRITERIA:

- Age more than 10 years and less than 70 years
- Patient with carpal, metacarpal , phalangeal fractures
- Both male and female
- Closed and displaced fractures

EXCLUSION CRITERIA:

- Age less than 10 years and more than 70 years
- Patient not willing or medically unfit for surgery
- Grade 3 Compound injury

IMPLANT PROFILE

1 mm AO mini plate (straight plate (for shaft fractures), L – plate& T – plate (for periarticular fractures). AO stainless steel implants are produced from implant quality 316L stainless steel which typically contains iron (62.5%),chromium (14.5%), nickel 2.8%), molybdenum and minor alloy elements, range from 28mm to 50mm, breadth: 5mm, Thickness: 1mm and holes: 4-8 holed.

EVALUATION OF OUTCOME:

For evaluating functional outcome of unstable metacarpal fractures treated with plate osteosynthesis, we used the American Society For Surgery OfThe Hand (ASSH) Total Active Flexion (TAF) scoring system. The system takes into account the degree of flexion at metacarpophalangeal joint, proximal and distal interphalangeal joints for digits (2-5), for thumb the degree flexion at metacarpophalangeal and interphalangealjoint. The extensor deficit is measured in degrees and the total active flexionscore is the sum of flexion at metacarpophalangeal joints and interphalangeal joints minus the extensor deficit.

Table-1:TAF from MCPJ to DIPJ: Digit 2-5

Degree of flexion	Rating
220-260	Excellent
180-220	Good
130-180	Fair
<130	Poor

Table-2:TAF from MCPJ and IPJ: Thumb

Degree of flexion	Results
120-140	Excellent
100-120	Good
70-100	Fair
<70	Poor

PRE OPERATIVE PREPARATION:

Base line blood investigations, x-rays –pre op,post op. A minimum of two views – anteroposterior and oblique – are mandatoryfor assessing: Degree of angulation, Amount of shortening and Presence of comminution.

PROCEDURE AND POSTOPERATIVE PROTOCOL:

All patients were admitted in casualty department and were resuscitated.If there were any major associated injuries they were treated accordingly at first.After the general condition of the patient improved, radiographs – anteroposterior and oblique views were taken. Fracture reduced in closed manner at first under sedation and volar below elbow slab was applied. Unstable fractures were taken up for surgery – open reduction and internal fixation with plate osteosynthesis. Most of the cases were taken up for surgery on the 1st or 2nd day of admission. Patient who were associated with major injuries were taken up for surgery between 5 to 7 days after admission after stabilisation.

SURGICAL PROCEDURE OPEN REDUCTION INTERNALFIXATION WITH PLATE OSTEOSYNTHESIS

Tourniquet was used in all the cases before surgery.Metacarpal and phalanx fractures are approached by dorsal incision made on radial border for the first and second metacarpal, ulnar border for thefifth metacarpal. For the 3rd and 4th metacarpals the approach is made using adorsal longitudinal incision made between these bones. Then extensor tendonswere retracted and anatomical reduction of the fracture fragments are carried out. Reduction is held using point reduction clamps or a stabilizing K wire. Interfragmentary lag screws were used in long spiral and oblique fractures. Plate configuration were chosen according to the fracture pattern (straight platefor shaft fractures, T or L configured plates were used for periarticular fractures)and fixed with screws. Meticulous attention was carried out in soft tissue dissection and adequate soft tissue coverage (periosteum) was made over theplate to avoid irritation to overlying extensor tendon. Thorough wound wash was given and wound closed in layers. Splinting of the hand was done with a volar below elbow slab.

POST OPERATIVE PROTOCOL:

Hand was kept in elevation for 24-48 hours for controlling pain and swelling. Wound was inspected at second post operative day. Thereafter, activemobilization of fingers started and increased progressively within the limits of pain tolerance. Patients were discharged on 5th post

operative day and physiotherapy carried out on outpatient basis. Sutures were removed on 12th postoperative day. Follow up was done at 4th, 6th and 8th weeks and assessed for clinical progress in terms of range of movements and radiological evaluation done to note fracture union or any loss of reduction.

PITFALLS AND THEIR MANAGEMENT:

Infection: One case developed wound infection, which was a superficial infection. Pusculture for sensitivity was sent and treated with appropriate antibiotics and regulardressings. The superficial infection subsided with treatment for 3 weeks and thatcase did not require implant exit.

Tendon irridation: One patient with phalangeal fracture developed tendon irritation and he was not able to extend the finger. The patient was put on strict physiotherapy involvingactive mobilization exercises.Since patient was not improved and implant exit wasdone. Thereafter a patient had improved range of movements following physiotherapy.

RESULTS:

20 patients were included in this study. Age group varied from 20 years to 70 years with mean age of 45 years.Incidence of fracture was observed maximum between 20-50 years. Among the 20 cases, males were predominant (19) and only one female. 5 patients had multiplemetacarpal fractures (25% cases). Right hand was involved in 14 of the patients (70%). 1 out of 20 were female patient (10%). All the 20 patients who underwentopen reduction and internal fixation with plate osteosynthesis for unstable metacarpal and phalangeal fractures achieved bone union (100%). In most of thecases bony union was seen between 6-8 weeks, average period being 7.2 weeks(range 6-12 weeks). Spiral and oblique fractures united at 6 weeks, transverse and comminuted fractures united at around 8 weeks. Commonest mode of injury being Road Traffic Accident (RTA) 12(60%), accidental fall3(15%) and assault 5(25%). Spiral fracture pattern being most common accounting for 55%(Table :6). 4 cases had associated other injuries Clavical fracture(3) and Posterior dislocation of hip(1)

Functional outcome assessed by ASSH (American Society for Surgery of the Hand) TAF (Total Active Flexion) score was excellent in 16 patients(80%), good in 2 patients (10%), fair in one patient (5%), poor in one patient (5%).The overall results are satisfactory. 2 Cases developed complications: Infection seen in 5% (1 out of 20 cases). Tendon irritation seen in 5% (1 out of 20 cases).

One patient developed superficial wound infection, which a case of proximal phalangeal fracture. This case with superficial infection settled with daily dressingand antibiotics. One patient had extensor tendon irritation and not able to extent the PIP and DIP joint. Since patient not improved with physiotherapy, implant exit was done. Then physiotherapy was continued and patient showed improved range of motion, and the results in this patient was fair.

None of the patients in our study developed stiffness, this is due to early mobilisation and regular physiotherapy and follow-up. No cases had angular or rotational displacement of fractures. No cases had implant breakage.

ANALYSIS OF FUNCTIONAL OUTCOME:

The functional outcome was assessed using AMERICANSOCIETY FOR SURGERY OF THE HAND (ASSH) TOTAL ACTIVE FLEXION SCORE (TAF) and the following results were obtained.

Table-3: ASSH-TAF SCORE – OVERALL RESULT

GRADING	NO OF CASES	PERCENTAGE
EXCELLENT	16	80
GOOD	2	10
FAIR	1	5
POOR	1	5

Table-4: SIDE OF INJURY

EX	RIGHT	LEFT	BILATERAL	TOTAL
Male	13	6	0	19
Female	1	0	0	1
Percentage	70	30	-	-

Table-5: **Number of metacarpal involved**

NO OF METACARPALS INVOLVED	NO OF CASES	PERCENTAGE
1	15	75
2	4	20
3	1	5
4	0	-
5	0	-

Table-6: **FRACTURE PATTERN**

FRACTURE CONFIGURATION	NUMBER OF CASES	PERCENTAGE
SPIRAL	11	55
OBLIQUE	1	5
TRANSVERSE	7	35
COMMINUTED	1	5

Fig-2: **TIME INTERVAL BETWEEN INJURY AND SURGERY**

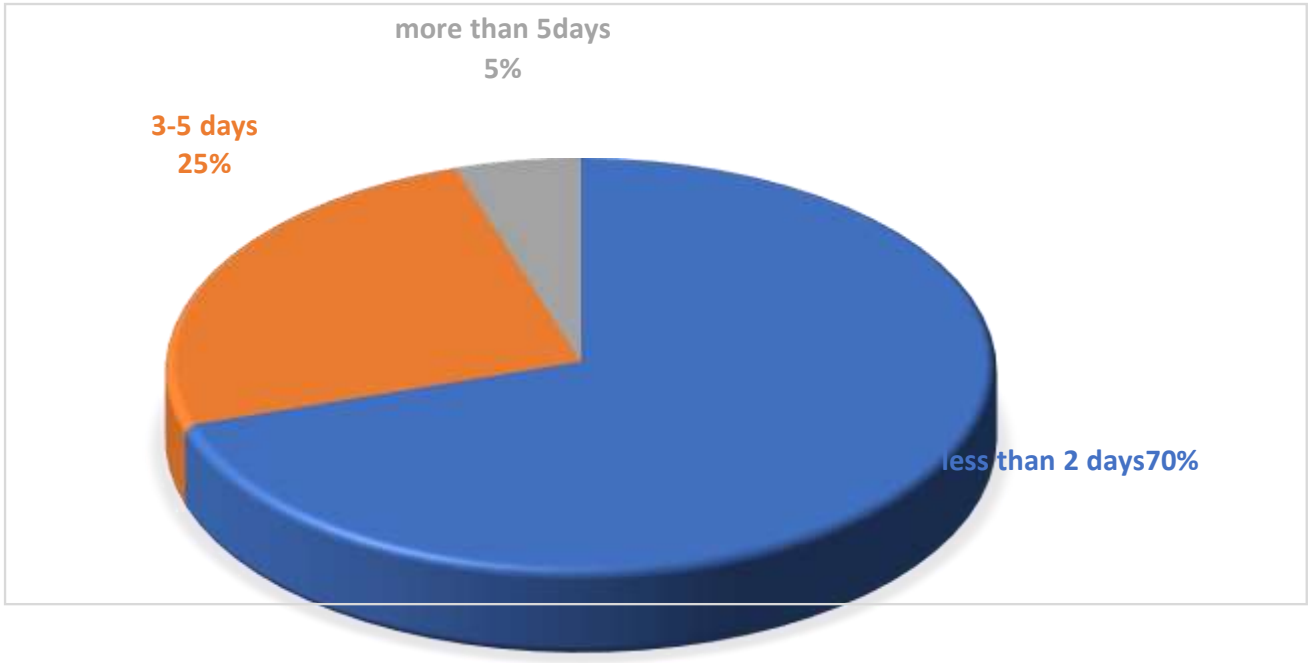
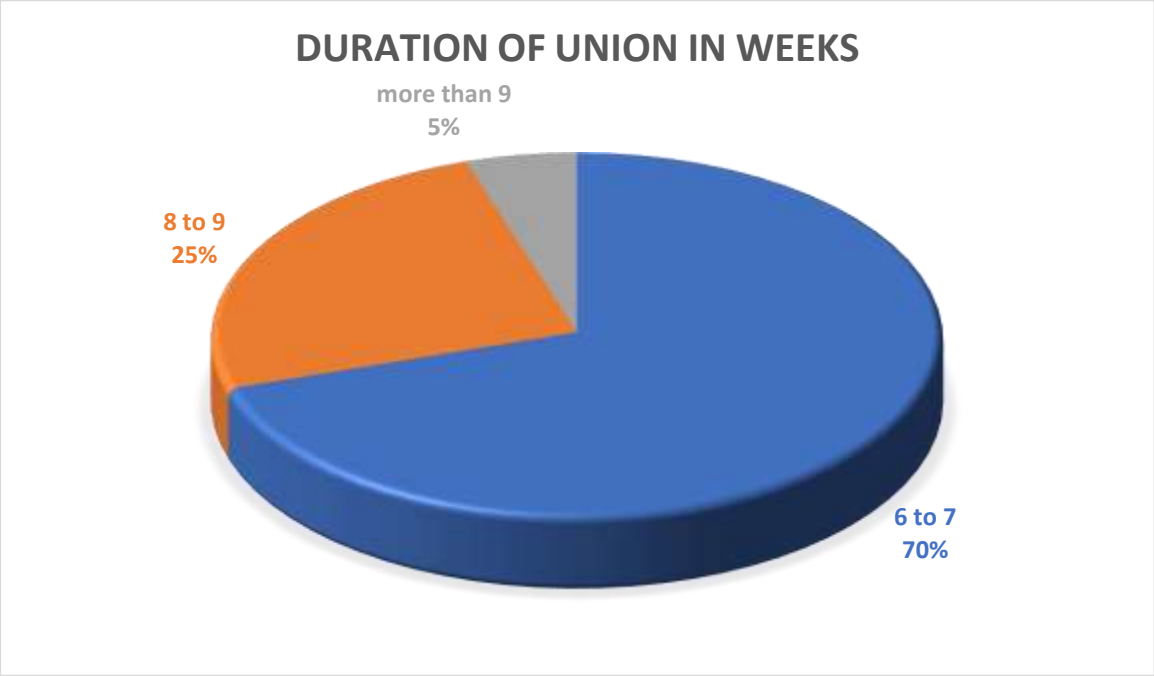
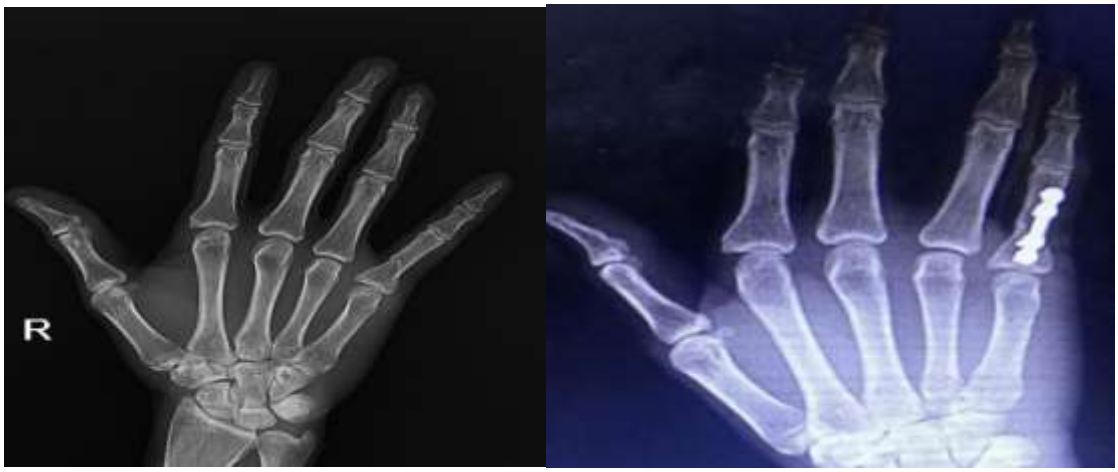


Fig-3: **UNION TIME**



In most of the cases bony union was achieved in 6-7 weeks accounting for 65%.

Fig-4: PREOP XRAY POSTOP XRAY



DISCUSSION:

Most of the metacarpal fractures are stable before or after closed reduction and are managed successfully by conservative method of protective splinting followed by early mobilization . Only a small percentage of metacarpal fractures are unstable and in these patients the functional results following closed treatment are unsatisfactory. These are the cases indicated for open reduction and internal fixation which are usually less than 5 % of hand fractures . James et al reported that closed method used in treatment of unstable fractures had loss of function in 77 % of fingers.

Open reduction and internal fixation with K wire is one of the treatment modalities in these unstable fractures but they provide less rigid fixation and are rotationally unstable, there is increased association of pin tract infection and problems due to protruding ends of K-wire are significant. Interosseous wiring with K- wire although provides rigid fixation equivalent to plating are useful only in transverse diaphyseal fractures.

Metacarpal fractures can be fixed with external fixator(14) . Report by Shehadi et al showed full return of total range of motions in up to

100% of metacarpal fractures treated with external fixator. This mode of fixation is useful in compound metacarpal fractures with bone loss. But the routine use of external fixator is discouraged as there is loosening of construct following pin tract infection leading to loss of fixation and there is difficulty in constructing and applying the fixator(15-17) .

Intramedullary fixation with prebent K- wires were used for transverse and short oblique fractures . They provide comparable functional outcome with plate and screw fixation. But there is incidence of loss of reduction, penetration of metacarpophalangeal joint by hardware, thus necessitating a second surgery for hardware removal.

There are many literature studies showing satisfactory results of unstable metacarpal and phalangeal fractures treated with AO miniplate and screws(18) . A study by Souer et al showed good functional outcome by total active motion more than 230 degree in 18 of 19 patients for whom plate fixation was done in closed unstable metacarpal and phalangeal fractures(19). Another study by Gupta et al showed excellent functional outcome with total active movements more than 230 degree in all of his patients of unstable metacarpal and phalangeal fractures treated with plate fixation(20). Another study by Dabezies Schutte showed no complication in 27 unstable metacarpal fractures treated with plate fixation. Low complication rate seen in our study was similar to these results(21-23).

In our study on 20 patients, 1 patient developed superficial wound infection. In this case of superficial infection, there was wound discharge on second post operative day which settled with daily dressing and antibiotics and this does not affect the final outcome. 1 Patient with proximal phalanx fractures developed tendon irritation and not able to extend the finger, where implant was removed and improved ROM following physiotherapy.

In unstable metacarpal and phalanx fractures, plate fixation is a better option for several reasons :

1) They provide stable fixation in all unstable metacarpal and phalanx fractures thus allowing early mobilization of fingers

2) Shortening seen in multiple metacarpal fractures which are corrected by plating restores the power of interossei muscle thereby retaining the grip strength of hand.

3) Multiple metacarpal fractures are usually associated with severe soft tissue injury. In these unstable metacarpal fractures, treatment with plate osteosynthesis provides anatomical reduction of fracture with rigid stabilization allowing early mobilization of joints without loss of reduction thus preventing stiffness and yields good functional results.

In our study of unstable metacarpal and phalanx fractures treated with plate osteosynthesis all the cases showed bone union (100%). The functional result assessed by American Society For Surgery Of The Hand (ASSH) Total Active Flexion score showed excellent result in 80% of the patients (16 of 20 cases), good in 10% of cases (2 of 20 cases). Stable and rigid fixation provided by mini plates and screws allowed early mobilization of fingers thereby preventing stiffness and achieved overall good functional results. Although there were 5% (1 case) of superficial infection, all settled with regular dressing

CONCLUSION:

Plate and screw fixation is a good option for treating closed unstable metacarpal and phalanx fractures, where other modalities of fixation are less effective, the rigid stable fixation provided by plating whichwithstands load without failure allowed early mobilization and achieved good functional results.

Detailed clinical and radiological assessment of fractures, carefulpreoperative planning, meticulous dissection, precision in surgical technique like coverage of plate with periosteum and soft tissue and choosing the correct implant like low profile plate are critical in achievingexcellent outcome and minimizing the complication.

Acknowledgment:

We sincerely thank each and every one of the participants for taking part in research study. The authors thank the Government Erode Medical College and Hospital, Perundurai, Tamil Nadu, for providing the necessary facilities.

IEC Approval:

Institutional Ethical Committee was approved for the study by the Government Erode Medical College and Hospital, Perundurai, Tamil Nadu. Personal identifiers such as names were not collected during the study.

Author Contributions: ,

Dr. R.Sakthive (RS) and Dr. N. Nandha Kumar (NN) had the idea for this study. Dr S Mohamed Azeem (SM) and Dr.B.Manimaran (BM) are the principal investigators of the research work. RS, NN designed the study protocol. SM performed data collection, BM conducted the analyses, and RS drafted the manuscript. RS, SM, NN and BM further edited the manuscript, and all gave the final approval.

Declaration of interests:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding:

There is no funding for this Project

References

1. Day C, Stern P. Fractures of the metacarpals and phalanges. In: Wolfe S, ed. Green's Operative Hand Surgery. 6th ed. Philadelphia: Elsevier Churchill Livingstone; 2011.
2. Stanton J, Dias J, Burke F. Fractures of the tubular bones of the hand. J Hand Surg Eur Vol. 2007;32(6):626–636.
3. Calandruccio J, Jobe M. Fractures, dislocations, and ligamentous injuries. In: Canale S, Beaty J, eds. Campbell's Operative Orthopaedics. 11th ed. Philadelphia: Mosby; 2008.
4. Henry M. Hand fractures and dislocations. In: Bucholz R, Heckman J, Court-Brown C, Tornetta P, eds. Rockwood and Green's Fractures in Adults. 7th ed. Philadelphia: Lippincott Williams & Wilkins; 2010.
5. Jupiter J, Axelrod T, Belsky M. Fractures and dislocations of the hand. In: Browner B, Jupiter J, eds. Skeletal Trauma: Basic Science, Management, and Reconstruction. 4th ed. Philadelphia: Saunders; 2009.
6. Van Derelst E. Les debuts de l'osteosynthese en Belgique. Brussels: Societe Belge de Chirurgie Orthopedique et de Traumatologie, Imprimerie des Sciences; 1973.
7. Lambotte A. Chirurgie: operatoire des fractures. Paris: Masson & Cie; 1913.
8. Harness N, Meals R. History of fracture fixation of the hand and wrist. Clin Orthop Relat Res. 2006;445:19–29
9. Souer, J. S., & Mudgal, C. S. (2008). Plate fixation in closed ipsilateral multiple metacarpal fractures. Journal of Hand Surgery (European Volume), 33(6), 740-744.
10. Cepni, S. K., Aykut, S., Bekmezci, T., & Kilic, A. (2016). A minimally invasive fixation technique for selected patients with fifth metacarpal neck fracture. Injury, 47(6), 1270-1275.
11. Viswanathan, M. (2016). FUNCTIONAL OUTCOME OF CLOSED METACARPAL FRACTURES TREATED WITH MINI PLATES AND SCREWS–A PROSPECTIVE STUDY. Int. J. Modn. Res. Revs, 4(10), 1280-1284.
12. Venkatesh, R., & Kerakkanavar, S. (2017). Functional outcome of closed metacarpal shaft fractures managed by low-profile miniplate osteosynthesis: A prospective clinical study. Journal of Orthopaedics & Allied Sciences, 5(2).
13. VENKATA MAHIPATHY, S. R. R., Ranganathan, S., Murugesan, S., Durairaj, A. R., & SUNDARAMURTHY, N. (2018). Analysis of Functional Outcome Following Rigid Skeletal Stabilisation of Unstable Proximal and Middle Phalangeal Fractures of the Hand. Journal of Clinical & Diagnostic Research, 12(5).
14. Wang, D., Sun, K., & Jiang, W. (2020). Mini-plate versus Kirschner wire internal fixation for treatment of metacarpal and phalangeal fractures. Journal of International Medical Research, 48(3), 0300060519887264.
15. Kandasamy, A. A., Pheroz, M., Kumar, A., Krishna, L. G., Jain, A., & Grower, R. (2019). Fractures of metacarpal bone: evaluation of functional outcome of open reduction and internal fixation with mini locking plate: a hospital based study. International Journal of Research in Orthopaedics, 5(3), 519.
16. .Gupta R, Singh R, Siwach RC, Sangwan SS. Evaluation of surgical stabilization of metacarpal and phalangeal fractures of hand. Indian J Orthop 2007;41(3);224-29.
17. .Jiaming Xu and Changqing Zhang Miniplate verses wire internal fixation for treatment of metacarpal and phalangeal fractures Xu and Zang journal of orthopaedic surgery and Research 2014,9:2464.
18. Al-Qattan MM, Al-Lazzam A: Long oblique/spiral mid-shaft metacarpal fractures of t he fingers: treatment with cerclage wire fixation and immediate post-operative finger mobilis
19. Buchler U, Fischer T: Use of a minicondylar plate for metacarpal and phalangeal periarticular injuries. Clin Orthop Relat Res 214:53–58, 1987.ation in a wrist splint. J Hand Surg Eur Vol 32:637–640, 2007
20. Burkhalter WE, Reyes FA: Closed treatment of fractures of the hand. Bull Hosp Jt Dis Orthop Inst 44:145–162, 1984.
21. Chung KC, Spilson SV: The frequency and epidemiology of hand and forearm fractures in the United States. J Hand Surg [Am] 26:908–915, 2001.
22. Fusetti C, Meyer H, Borisch N, et al: Complications of plate fixation in metacarpal fractures. J Trauma 52:535–539, 2002.
23. Galanakis I, Aligizakis A, Katonis P, et al: Treatment of closed unstable metacarpal fractures using percutaneous transverse fixation with Kirschner wires. J Trauma 55:509–513, 2003.